

Sources of Exposure

Toxicokinetics and Normal Human Levels

Biomarkers/Environmental Levels

ToxGuide™

for Lead

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General Populations

- The most likely source of exposure is ingestion of contaminated food and drinking water. Exposure can also occur via inadvertent ingestion of contaminated soil/dust or lead-based paint.
- Lead can leach into drinking water from lead-soldered joints or leaded pipes in water distribution systems or individual houses. Lead may also enter foods if they are put into improperly glazed pottery or ceramic dishes.
- Other potential sources of exposure are hobbies that use lead: casting ammunition and fishing weights; soldering with lead solder; making stained glass; and using firing ranges. Leaded gasoline is still used in some race cars, airplanes, and off-road vehicles.
- Some non-Western folk remedies may contain substantial amounts of lead. Some types of hair dyes and imported cosmetics may contain lead compounds.

Occupational Populations

- Potentially high levels of lead may occur in the following industries: lead smelting, mining, and refining industries, battery manufacturing plants, steel welding or cutting operations, construction, firing ranges, radiator repair shops, and other industries requiring flame soldering of lead solder.

Toxicokinetics

- Following inhalation of organic lead, approximately 60–80% of lead deposited in the airway is absorbed.
- Gastrointestinal absorption of inorganic lead is influenced by the physiological state of the exposed individual and the species of the lead compound.
- Gastrointestinal absorption of lead is higher in children (40–50%) than in adults (3–10%). The presence of food in the gastrointestinal tract decreases absorption.
- Absorption of lead from soil is less than that of dissolved lead but is similarly depressed by meals (26% fasted; 2.5% when ingested with a meal).
- In adults, about 94% of the total amount of lead in the body is contained in the bones and teeth versus about 73% in children.
- Lead remains in bones for decades and in blood for months.
- Independent of the route of exposure, absorbed lead is excreted primarily in urine and feces.

Blood Lead Levels

- Lead levels in blood in the United States (geometric mean, National Health and Nutrition Examination Survey [NHANES] 2015–2016):
 - 0.76 µg/dL for children 1–5 years
 - 0.92 µg/dL for adults >20 years
- The Centers for Disease Control and Prevention (CDC) reference value is 5 µg/dL.

Biomarkers

- Analysis of lead in whole blood is the most common and accurate method of assessing lead exposure. Lead in blood reflects recent exposure.
- Bone lead measurements are an indicator of cumulative exposure.
- Measurements of urinary and hair lead levels have been used to assess lead exposure; however, they are not as reliable.

Environmental Levels

Air

- The mean air levels of lead in samples collected in the United States in 2008–2010 were 0.20 µg/m³ for source-oriented and 0.012 µg/m³ for nonsource-oriented.

Soil

- The natural lead content of soil typically ranges from 15 to 20 µg/g. However, lead levels in the top layers of soil vary widely due to deposition and accumulation of atmospheric particulates from anthropogenic sources.

Water

- Lead levels in surface and groundwater can be highly variable. Recent U.S. surface water mean concentrations were reported to be 4 µg/L.

Reference

Agency for Toxic Substances and Disease Registry (ATSDR). 2020. Toxicological Profile for Lead. Atlanta, GA: U.S. Department of Health and Human Services, Public Health Service.



Chemical and Physical Information

Routes of Exposure

Relevance to Public Health (Health Effects)

Lead is a Metal

- Lead is a naturally occurring metal that is rarely found in its elemental form. It occurs in the Earth's crust primarily as the mineral galena (PbS), and to a lesser extent as anglesite (PbSO₄) and cerussite (PbCO₃).
- Lead is not a particularly abundant element, but its ore deposits are readily accessible and widely distributed throughout the world. Due to its properties, such as corrosion resistance, density, and low melting point, lead has been a commonly used metal in pipes, solder, weights, and storage batteries.

- Inhalation** – Primary route for occupational exposure. Larger particles (>2.5 μm) that are deposited in the ciliated airways (nasopharyngeal and tracheobronchial regions) can be transferred by mucociliary transport into the esophagus and swallowed.
- Oral** – Primary route of exposure for the general population.
- Dermal** – Organic lead compounds can be absorbed through the skin.

Lead in the Environment

- Lead is dispersed throughout the environment primarily as the result of anthropogenic activities. In the air, lead is in the form of particles, and is removed by rain or gravitational settling.
- The fate of lead in soil is affected by the adsorption at mineral interfaces, which are dependent upon physical and chemical characteristics of the soil (e.g., pH, soil type, particle size, organic matter content).
- Sources of lead in dust and soil can include lead from weathering and chipping of lead-based paint from buildings, bridges, and other structures.
- The solubility of lead compounds in water is a function of pH, hardness, salinity, and the presence of humic material. Solubility is highest in soft, acidic water.

Health effects are determined by the dose (how much), the duration (how long), and the route of exposure.

Minimal Risk Levels (MRLs)

- Epidemiological studies show that effects occur at the lowest blood lead levels studied (≤5 μg/dL). Because the lowest blood levels are associated with serious adverse effects (e.g., declining cognitive function in children), MRLs for lead have not been derived.

Health Effects

Numerous studies have evaluated the effects of lead in workers and the general population. Exposure to lead is associated with toxicity to every organ system that has been studied. Effects in the following systems are the major effects of lead and are associated with blood lead levels ≤10 μg/dL.

- Neurological (children):** decreased cognitive function, including lower IQ; altered mood and behaviors including attention deficits, hyperactivity, autistic behaviors, conduct disorders, and delinquency; altered neuromotor and neurosensory function.
- Neurological (adults):** decreased cognitive function including attention, memory, and learning; alterations in mood and behavior; altered neuromotor and neurosensory function.

- Renal:** decreased glomerular filtration rate; proteinuria.
- Cardiovascular:** increased blood pressure; increased risk of hypertension.
- Hematological:** decreased activity of several heme biosynthesis enzymes; decreased hemoglobin levels.
- Reproductive (males):** decreased sperm count, concentration, motility, and viability.
- Reproductive (females):** spontaneous abortion; preterm birth.
- Developmental:** decreased birth weight and size; decreased anthropometric measures in children; delayed onset of puberty in males and females.

Children's Health

- Children are more vulnerable to the effects of lead than adults.
- The most common source of lead exposure for children is lead-based paint.
- Lead exposures either during gestation, infancy, or during childhood may result in delays or impairment of neurological development, neurobehavioral deficits, low birth weight, decreased gestational age, growth retardation, and delayed sexual maturation in girls.
- Ensuring a diet that is nutritionally adequate in calcium and iron may decrease the absorbed dose of lead.